

MICROBIAL TREATMENT OF COALS AND ITS EFFECT ON ASH FUSION PROPERTIES

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INTRODUCTION

Coal is a major source of energy in the United States, generating roughly 50% of the total electricity power produced, and 90% of the electricity used east of the Mississippi River. Coal usage for electrical power generation currently averages 550-600 million ton/yr, and is expected to increase despite diminishing quantities of high-quality (i.e., low sulfur content, low fouling) coals. Increasingly stringent regulatory standards for reduced levels of atmospheric sulfur emissions have increased demand for low-sulfur coal. The primary objection to high-sulfur coal is the consequent generation of sulfur oxides during combustion, which may play a major role in the formation of acid rain.

In addition to sulfur, the quantity of metals in the coal also affects coal quality. Metals which may be present, mostly in the form of minerals and sulfides, include Si, Fe, Ca, Mg, Al, Na, K, and Ti, as well as traces of As, Cd, Cr, Cu, Pb, Mn, Hg, Ni, and Zn. Coal combustion oxidizes these metals to produce significant quantities of coal ash, the disposal of which can be costly. Additionally, ash entrained with the hot combustion gas tends to foul heat exchange surfaces, which reduces furnace efficiency and causes operational difficulties. The presence of metals like Arsenic, Lead, and Mercury create problems in disposal of ash.

The most common techniques of coal beneficiation are physical separation methods which exploit density differences between the light organic coal and heavier inorganic impurities. Numerous chemical processes involving reaction and extraction have been proposed. However, these methods generally prove uneconomic due to the high temperature and pressure required to achieve desired removal of impurities. The use of microbial processes in various aspects of energy production has become increasingly important over the past several years. In particular, the isolation and characterization of bacteria which catalyze the solubilization of sulfur compounds in coal and petroleum has suggested the possibility of a biological approach to fossil fuel desulfurization.

Microbial desulfurization of coal presents some important advantages over physical/chemical processes. Ambient temperature and pressure are generally sufficient to promote good microbial growth. The microbes are self-regenerating, so the costs are minimal. Microbial processes offer the possibility of removing not only inorganic sulfur, but also organic sulfur in the coal.

Processes involving the microorganism *Thiobacillus ferrooxidans* have been considered as an alternative to desulfurization by physical and chemical methods. In addition to desulfurization, it may also be effective in removing pyritic iron, Ca, Mg, Al, Na, K, Pb, Mo, Zn, Cu, and Cr. This concurrent demetalization of the coal may enhance the relative economic attractiveness of microbial desulfurization by reducing the quantity of ash produced and improving the quality of the ash.

OBJECTIVES AND APPROACH

One objective of this study was to characterize the microbial demetalization and desulfurization of coal by the bacterium Thiobacillus ferrooxidans under aerobic conditions. The effects of type of coal, coal particle size, and nutrient concentration on the bacterial leaching of coal were investigated. Ash fusion temperatures of treated and untreated coal samples were measured and an attempt was made to relate variations to the coal and ash properties.

Another objective was to determine the extent of dissolution of different metals from coal residues by the action of native autotrophic bacteria under aerobic conditions. The effects of inorganic nutrient supplements were also studied.

RESULTS AND DISCUSSION

The major results from the aerobic demetalization and desulfurization tests on three bituminous coal are summarized in Table 1. It is obvious that the effectiveness of microbial treatment is dependent on the type of coal and coal ash. More significantly, it can lead to substantial improvements in ash quality (as defined by the ash fusion temperature) as seen with the Pittsburgh Coal.

Some results from aerobic dissolution of toxic metals from the fines fractions of coal residues are summarized in Table 2. It is clear that under aerobic conditions substantial fractions of other metals in addition to pyritic iron can be solubilized from coal or coal residues.

CONCLUSIONS

Microbial action on bituminous coals under aerobic conditions can lead to significant reductions in inorganic sulfur, metals and total ash content, as well as considerable increase of ash fusion temperatures of the remaining ash.

Table 1

Coal	Ash Content (%)	Ash Reduction (%)	Inorganic Sulfur Reduction (%)	Increase in Ash Fusion Temperature (°F)
Ohio	25.2	15	80	180
Pittsburgh	10.3	17.5	40	460
Illinois	8.1	27	40	50

Table 2

Metal	Control	With No Nutrients Added	With Nutrients Added
	% Metal in Solution		
As	0.69	6.1	47
Cr	7.7	11	65
Cu	2.4	10	33
Fe (III)	0.1	2.7	26
Mn	16	16	43
Ni	15	20	44
Pb	0.6	0.6	4.6
Zn	8.2	17	48